SALMON RECOVERY SCIENCE REVIEW PANEL
Report for the meeting held
June 19-21, 2002
Northwest Fisheries Science Center
National Marine Fisheries Service
Seattle, WA

This introductory material (pp. i-iii) is available on the RSRP web site, but as an aide to the reader we are now including it with individual reports.

Robert T. Paine	**University of Washington, chair**
Ted Case	**University of California – San Diego**
Frances James	**Florida State University**
Russell Lande	**University of California – San Diego**
Simon Levin	**Princeton University**
William Murdoch	**University of California – Santa Barbara**
Beth Sanderson	**NOAA Fisheries liaison**
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Recovery Science Review Panel

The Recovery Science Review Panel (RSRP) was convened by the NOAA Fisheries to help guide the scientific and technical aspects of recovery planning for listed salmon and steelhead species throughout the West Coast. The panel consists of six highly qualified and independent scientists who perform the following functions:

1. Review core principles and elements of the recovery planning process being developed by the NOAA Fisheries.

2. Ensure that well accepted and consistent ecological and evolutionary principles form the basis for all recovery efforts.

3. Review processes and products of all Technical Recovery Teams for scientific credibility and to ensure consistent application of core principles across ESUs and recovery domains.

4. Oversee peer review for all recovery plans and appropriate substantial intermediate products.

The panel meets 3-4 times annually, submitting a written review of issues and documents discussed following each meeting.

Expertise of Panel Members

Panel members have all been involved in local, national and international activities. They have served on numerous National Research Council committees and have published many papers in prestigious scientific journals.

Dr. Robert Paine (chair), University of Washington
- *Field of expertise*: marine community ecology, complex ecological interactions, natural history
- *Awards*: National Academy of Sciences member; Robert H. MacArthur award recipient from the Ecological Society of America; Tansley Award from the British Ecological Society; Sewall Wright Award from the American Society of Naturalists; Eminent Ecologist Award from the Ecological Society of America
- *Scientific leadership*: Member of multiple National Research Council committees, editorial boards, past president of Ecological Society of America
- *Research*: About 100 scientific publications

Dr. Ted Case, University of California-San Diego
- *Field of expertise*: evolutionary ecology, biogeography and conservation biology
- *Awards*: Board member for National Center for Ecological Analysis and Synthesis; Research featured in prominent scientific journals (Science, Nature) popular science journals (American Scientist, Discover), on public television and public radio
- *Scientific leadership*: Chair of Department of Biology at UCSD and author of leading textbook on theoretical ecology;
- *Research*: More than 116 scientific articles published

Dr. Frances C. James, Florida State University
- *Field of expertise*: conservation biology, population ecology, systematics, ornithology
- *Awards*: Eminent Ecologist Award from the Ecological Society of America; Leadership and dedicated service awards from the American Institute of Biological Sciences
- *Scientific leadership*: Participant on National Research Council Panels; service on many editorial boards; Board of Governors for The Nature Conservancy; scientific advisor for national, state and local activities
- *Research*: More than 105 scientific articles published

Dr. Russell Lande, University of California-San Diego
- *Field of expertise*: evolution and population genetics, management and preservation of endangered species, conservation and theoretical ecology
- *Awards*: Sewall Wright Award from the American Society of Naturalists; Guggenheim Foundation, MacArthur Foundation, American Academy of Arts and Sciences; Fellow of the American Academy of Arts and Sciences
- *Scientific Leadership*: President of the Society for the Study of Evolution; International recognition; developed scientific criteria for classifying endangered species adopted by the International Union for Conservation of Nature and Natural Resources (IUCN)
- *Research*: More than 116 scientific publications

Dr. Simon Levin, Princeton University
- *Field of expertise*: theoretical/mathematical ecologist
- *Awards*: National Academy of Sciences member; Robert H. MacArthur award recipient from the Ecological Society of America; Statistical Ecologist Award from the International Association for Ecology; Distinguished Service Award from the Ecological Society of America

- *Scientific leadership*: Member of many National Research Council committees; Board of Directors member for Santa Fe Institute, Beijer International Institute of Ecological Economics, the Committee of Concerned Scientists
- *Research*: More than 275 technical publications

Dr. William Murdoch, University of California Santa Barbara
- *Field of expertise*: theoretical and experimental ecologist, population ecology
- *Awards*: Robert H. MacArthur award recipient from the Ecological Society of America; President's Award from the American Society of Naturalists; Guggenheim Fellowship
- *Scientific leadership*: Founder of National Center for Ecological Analysis and Synthesis; Director of Coastal California Commission 10-year study; scientific advisory panel member for the Habitat Conservation Plan for the California marbled murrelet
- *Research*: More than 118 scientific publications

Dr. Beth Sanderson
- NOAA Fisheries liaison to the Recovery Science Review Panel
- Recovery Science Review Panel report coordinator

RECOVERY SCIENCE REVIEW PANEL (RSRP)
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I.   MONITORING IN GENERAL:

In the first RSRP report, the panel emphasized the need for an integrated and comprehensive program for monitoring. The comprehensive monitoring program described in the Basinwide Recovery Strategy (All-H paper) and the NMFS 2000 FCRPS BiOp is a hierarchical program organized around 3 tiers. Tier 1 monitoring, or landscape scale assessment of watershed status and population distribution, is a long period (3-10yr) census based effort that will rely heavily on remote sense data and GIS data layer development. Tier 2 monitoring, or habitat and population status and trend monitoring, is a probabilistically based annual sampling program to assess the status of tributary habitat and the demographic units it supports. Tier 3 monitoring, or restoration action effectiveness monitoring, assess the biological benefit of individual or suites of recovery actions in an experimental context. The 3 tiers are tightly interrelated; for example, the Tier 1 information forms the context underlying the design of the statistical sampling program for Tier 2, while the Tier 3 monitoring verifies the habitat and population indicators assessed at the Tier 1 and 2 scales.

Indeed, these various actions and projects are the main potential learning opportunity in salmon recovery. Document 1, which was given to the panel, as well as the presentations by Drs. Chris Jordan and Steve Katz, lay out just such a comprehensive and integrated monitoring plan. This plan responds not only to the need for comprehensive monitoring (Tier 3 type monitoring), but would integrate that information with monitoring aimed at estimating fish abundance and trends and the relationships between habitat characteristics and fish status (Tier 2). We cannot comment on the plan in detail, but its goals and general approach are entirely appropriate.

We encourage early and frequent contact between the NOAA Fisheries group working on developing this plan and the TRTs to ensure that the needs of the latter are reflected in the plan. In particular, TRTs work with "populations" as their management unit, and monitoring plans need to be designed so that TRTs can relate the data to these units.

The panel strongly recommends that NOAA Fisheries and other agencies involved in recovery planning support the further development of this plan and its broad implementation. We further recommend that agencies funding habitat improvement and other projects require standardized Tier 3 monitoring of projects and standardized data collection of relevant variables for future meta-analyses of the effects of these projects. The panel intends to spend more time on the subject of monitoring and habitat-fish relationships at a future meeting and expects to provide at that time more detailed recommendations.

Bruce McIntosh described the Oregon Plan and its associated coastal monitoring of status, trends and habitat at multiple scales. This monitoring program implements EMAP (Environmental Monitoring and Assessment Program), a sampling design that allows for spatially stratified random sampling. It is a comprehensive program that collects standardized data on fish abundance and trends and on habitat variables. It creates the potential to develop data-based relationships between habitat characteristics and fish status. For instance, one important result, based on surveys of a number of hatchery/non-hatchery salmon on spawning grounds, has led to a reduction of the hatchery fish contribution. Because this program appears to be a successful example of a rigorous sampling design that achieves its goals with acceptable precision at relatively low cost ($2 M/yr), NOAA Fisheries should consider, with the cooperation of state salmon managers, extending this Oregon program to Washington, California and Idaho. It appears to correspond to Tier 2 monitoring in the NOAA Fisheries plan.

Almost all long-term data sets used to evaluate population trends and lambda are based on fish returning from marine to fresh waters. Selena Heppel presented an argument that monitoring outmigrants would reveal changes in fresh water carrying capacity (k), and might possibly also provide insights into the relative contributions of fresh water vs. marine phases to salmon population trends.

In summary, we urge that NOAA Fisheries, other federal agencies and state units develop a comprehensive monitoring program that is independent of place, habitat and species. Achieving such a goal could lead to more global generalizations, enhance research organizations and provide general advice to the TRTs. Effort should be taken to disabuse all agencies that "monitoring" is a waste of time. Stock and habitat assessment is essential to both setting recovery goals and knowing when they have been reached. Effective and efficient monitoring provides an essential ingredient to good science.

II.   MONITORING: METHODOLOGIES, MODELS AND ANALYSES

The committee was presented with preliminary monitoring plans from two TRTs, Puget Sound and Willamette. In each, a set of six kinds of methods played a central role:

> (1) Population Viability Analysis (PVA)
> (2) Habitat Productivity Viability Analysis (HPVA/PFC)
> (3) Maximum Historical Habitat Capacity
> (4) Historical Abundance
> (5) Viability Risk Assessment Procedure (VRAP)
> (6) Migrant Equilibrium Analysis (MEA)

These methods use different criteria and provide different levels of reliability. Furthermore, satisfying one can often be at the expense of satisfying another. A clear road map is needed — basically, a decision tree — as to how these will be integrated with and played against one another. Maximum Historical Habitat Capacity and Historical Abundance would be useful measures, but no methods exist to unambiguously estimate these. Furthermore, VRAP and MEA are in early stages of development.

Which are the most important among these six methods and why? A variety of criteria are proposed, but the documents need to do a better job of clarifying which criteria are more scientifically based and which represent compromises based on other considerations. It also must be made clear how the six methods are traded off against one another and how a hierarchical scheme for decision-making can be defined.

Discussion of the criteria also must be tightened considerably. For example, a quasi-extinction threshold needs to be defined. Second, it must be made clear that PVA (as well as HPVA/PFC) does not predict equilibrium abundance levels, as the Puget Sound document claims, but rather identifies those mean abundance levels that would be needed to sustain a viable population. Third, the statement that "the population is just replacing itself" should be modified with "on average," to reflect the role of stochasticity. There is no room for sloppy writing in these documents. They may serve as bibles for decision-making in the future.

Most importantly, it is crucial that all of the TRTs adopt a common framework for decision-making that is based on sound and defensible scientific determinations. Obviously, the details of implementation will vary from TRT to TRT because of physical and biological differences among the regions. However, a common basis should apply to all TRTs, and should be laid out in a single document that is agreed upon and applies to all. Anything less is certain to engender challenges based on apparent arbitrariness. We recommend that inter-TRT discussions be initiated to develop that common basis, which should then serve as the first chapter in each TRT's monitoring strategy document.

III. VIABILITY

The RSRP committee remains concerned that despite repeated admonitions against relying primarily on quantitative population models for setting recovery/delisting criteria, our suggestion to develop a simple, but objective population-based system for listing/delisting criteria similar to the IUCN Red List Criteria has had no noticeable impact on the work of the Willamette/Lower Columbia TRT.

IV. ALL-H ANALYSIS

The all-H analysis is investigating the overall relationship between trends in salmon abundance during a 20-year period and various H factors. Jon Hoekstra presented his team's preliminary analysis at the meeting. He and his collaborators are working on a project to analyze the negative effects of habitat degradation, hydropower dams, hatcheries and harvest (the 4Hs) on populations of salmon in the Pacific Northwest.

Chuck McCulloch, a statistician at the University of California San Francisco Medical School, had agreed to join the group in a conference call to discuss the analysis, but because of technical problems with the phone, that plan was thwarted. Hoekstra discussed the matter with him the following week.

The All-H analysis team worked for several months to put together a large data set in which the key dependent variable is lambda, the population trend of adult salmon from 1980 to 2000 in each of many small watersheds where salmon reproduce.

The committee was not satisfied with the preliminary analysis, which used a two-stage combination of factor analysis and path analysis. The objective was to use the factor analysis to reduce information from a set of variables for each H to a set of scores, and then to use those scores in the path analysis. The set of predictor variables that was in the factor analysis included variables like variance in harvest, which did not seem logically related to causes of declines. While this approach might yield insight into the relationship between management/habitat changes and salmon populations, the amount of variance explained so far is not encouraging.

Another problem was that the factors themselves did not always account for a reasonably large fraction of the variance in their components. In addition, there were several indicators that the analysis was flawed. The results of the path analysis were counterintuitive, with hydropower having a barely measurable influence on population declines. Hoekstra's subsequent memo to the committee acknowledged that using a preliminary factor analysis to obtain scores for each H has several drawbacks. The major drawback is that it will make the results of the path analysis uninterpretable in terms of the original variables.

An additional concern is that basing the analysis on the trend in salmon in the last 20 years ignores major environmental insults to salmon that occurred prior to that time frame. Even though attempts to restore salmon to historic levels may be unrealistic, we still want to know what factors, if changed, could have the highest restorative power, and that may require studying the system at a longer time frame. Even if such an analysis used only qualitative information about historical land use practices, harvest, etc., it might be informative. The committee suspects that the basic message reached so far may be incorrect and recommends that the analysis group consider broadening their purview to include estimated changes in salmon stocks over a longer period.

McCulloch has recommended trying either a guided backward elimination regression or a path analysis, preferably the former. He strongly recommends against doing a preliminary factor analysis. We agreed that the use of traditional regression methods in a single analysis would be preferable. McCulloch's suggestion for an alternative to the current approach is to include within location changes in the model. The advantages of including time series data in the analysis are:

(1) It can handle unequal lengths of data;
(2) It incorporates time-varying predictors (like the construction of a dam or changes in land use);
(3) It doesn't confound changes within a location due to a known predictor with estimation of lambda;
(4) The use of time-varying within location predictors can strengthen causal interpretations.

The disadvantages are that the data are complicated and require handling multiple levels of correlation (within a watershed, within upstream locations, etc.). Also, the method used to estimate lambda would have to be generalized to include covariates and correlations. This is a challenging suggestion. We recommend that it be explored for the Columbia Basin, where the data are better than for elsewhere. It certainly makes sense that the strongest causal inferences will come from within rather than between location comparisons. By working with the raw time by location data, the group probably has a better chance of getting the basic message right. The 4H analysis presents challenging data analysis problems. We recommend that Hoekstra work closely with McCulloch as he progresses with the project.

Ideally, we would like to determine the contribution of various factors to the historic declines in salmon abundance, and hence to the current reduced levels of abundance of salmon stocks. It may be possible to use two dependent variables:

(1) Fraction or number of historic populations now extinct. (This variable should be relatively easy to estimate.)
(2) Fractional decline from historic abundance.

Variable 2 is much harder to estimate because historic abundance is generally not known. However, it may not be necessary to estimate historic abundance with great precision, provided the range of fractional declines is large. One approach to obtaining such estimates would be to use a physical measure of habitat size for each watershed, using a reduced version of the type of approach being developed by Steel and Sheer (but avoiding, at least at present, detailed assumptions about habitat quality). Such estimates would need to recognize regional differences in types of watersheds. It might then be possible to test the validity of the estimates by comparing them with the admittedly sparse information on historic abundances. The latter could be, for example, early estimates of numbers or cannery data for a set of watersheds combined.

It was suggested at the panel meeting that it might be better to carry out the suggested 4H analyses only within each region. It seems better to retain the broadest geographic coverage, but perhaps to explore the effect of region as part of the analysis.

The potential value of such an analysis is that it could suggest which recovery actions would yield the greatest increase in salmon abundance. However, it should be recognized that continued focus on the 4Hs automatically discounts or ignores a host of other factors known to have an influence on lambda. Perhaps the dominant factor is the role of ocean conditions. Others are native birds, which may take as much as 10% of the outmigrating smolts, introduced species, which compete with (e.g., shad) or prey on salmon (e.g., bass, wall-eye, etc.), ungated irrigation or substantial reduction in the amount and quality of estuarine habitats. If these additional factors had little impact on lambda and stock variation, they could be ignored. It seems, however, that this is unlikely.

CONCLUDING REMARKS

Two general themes permeated the discussions at the meeting. One is recurring and represents a deepening RSRP committee concern. The second is new, but it potentially impacts the quality of recovery decisions made by the TRTs.

- We believe institutional changes are necessary if NOAA Fisheries is to meet its mandate. Structural problems seem to be impeding the conduct of necessary science. This seems true both within NOAA Fisheries and, especially, in its relationship with other federal and state agencies. Further, within NOAA Fisheries there needs to be more dialogue between science and policy units. This will be critical in setting reasonable harvest quotas, and in resolving the ongoing discussion on the relative merits of using trends in lambda or population numbers.

- Monitoring of stock numbers and habitat condition is of fundamental importance to understanding salmonid population trends. It should be made as scientifically and statistically rigorous as possible. Scientifically designed monitoring will generate information of great value, especially if employed to test competing hypotheses. It provides much of the data vital to assessing salmonid trends and the related management decisions.